

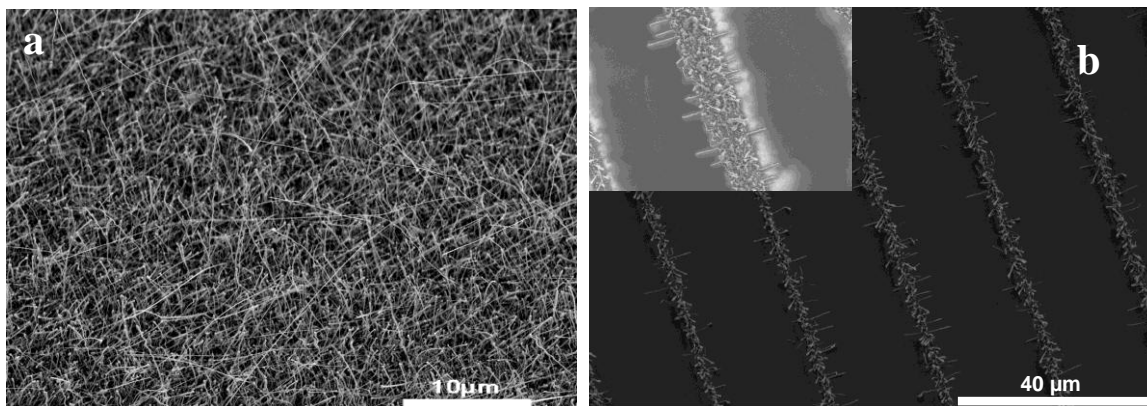
HVPE and VLS-HVPE synthesis of vertical and horizontal GaN nanowires

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The group III-N semiconductors nanowires (NWs) have attracted extensive interest for applications in electronic and optoelectronics.

However, GaN NWs are mainly grown using Molecular Beam Epitaxy (MBE) and Metal Organic Vapor Phase Epitaxy (MOVPE) methods. Until now only few groups have reported the catalyst-assisted growth of GaN NWs by Hydride Vapor Phase Epitaxy (HVPE). HVPE makes use of chloride III-Cl and hydride V-H3 gaseous growth precursors. It is known as a near-equilibrium process, providing the widest range of growth rates from 1 to more than 100 $\mu\text{m}/\text{h}$. When it comes to metal catalyst-assisted VLS (vapor-liquid-solid) growth, the physics of HVPE growth is maintained: high dechlorination frequency, high axial growth rate of nanowires (NWs) up to 100 $\mu\text{m}/\text{h}$. The remarkable features of NWs grown by HVPE are the untapered morphology with constant diameter and the stacking fault-free crystalline phase [1-3].

In this work, a complete study of the growth GaN NW is presented. The influence of the experimental parameters such as the substrate, the nature and the quantity of catalyst, the growth temperature, the flow rate and the V/III ratio is investigated. Vertical and horizontal GaN NWs with exceptional lengths are synthesized by VLS coupled with near-equilibrium HVPE process on silicon and *c*, *r* and *m*-plane sapphire substrates. Because of the high decomposition frequency of GaCl precursors and a direct supply of Ga through the catalyst droplet, the growth of GaN nanowires with constant diameters takes place at an exceptional growth rate up to 70 $\mu\text{m}/\text{h}$. The use of Au-Ni droplet suggests that the growth mechanism involves either VLS or VSS (vapour-solid-solid) interface. However, the growth temperature used in this study to synthesis long GaN NWs is upper the eutectic melting temperature for the Au-Ni system, suggesting that the growth of GaN NW occurs most likely via the VLS mechanism.



SEM images (a) of the vertical GaN nanowires grown for 30 min and (b) horizontal GaN nanowires grown for 10 min on *c*-plane sapphire substrate

[1] K. Lekhal; G. Avit et al. *Nanotechnology* **23** 405601 (2012)

[2] G. Avit; K. Lekhal et al. *Nanoletters* **14** 559 (2014)

[3] E. Gil; V. Dubrovskii; Y. Andre; G. Avit; K. Lekhal et al. *Nanoletters* doi.org/10.1021/nl501239h (2014)